

GEOPHYSICAL VARIABLES AND BEHAVIOR: C. INCREASED GEOMAGNETIC ACTIVITY ON DAYS OF COMMERCIAL AIR CRASHES ATTRIBUTED TO COMPUTER OR PILOT ERROR BUT NOT MECHANICAL FAILURE¹

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Summary.—Global geomagnetic activity (aa values) for the days of crashes of airplanes and for each of the three days before and after the crashes were compared for 373 events (years 1940 through 2002) attributed to unknown factors, mechanical errors, electronic/computer failures or pilot errors. Interactions between days and classifications of the crashes were due to the significantly greater geomagnetic activity on the days of crashes attributed to pilot or computer error but not to mechanical or unknown factors. Successive temporal analyses indicated that the elevated activity on the days of crashes attributed to pilot error have not changed over time, but there was an increase in those attributed to electronic errors after 1965. No more than 9% of the variance in geomagnetic activity on the days of the crashes was associated with the type of crash. These results are consistent with our hypothesis that some factor or factors associated with relative increases in geomagnetic activity may affect complex electronic systems composed of either silica (computer) or carbon (brain) aggregates.

Human and nonhuman complex electronic systems are immersed with in the earth's magnetic field. Increased geomagnetic activity is defined as irregular, time-varying alterations within the mHz range with peak-to-peak intensities between 20 nT and several hundreds of nanoTesla. These periods have been moderately correlated (r_s between .3 and .5) with increased numbers of neuroelectrical disturbances, such as limbic or temporal lobe seizures, in populations of rats and humans (Michon & Persinger, 1997).

Persinger (1991) reported a moderate strength correlation between the numbers of sudden impulses or rapid changes (primarily increases) in geomagnetic activity and the numbers of air crashes during a 2-yr. period. A more thorough examination by Komarov, Oraevsky, Sizov, Tsiryulnik, Kanonidi, Ushakov, Shalimov, Kimlyk, and Glukhov (1998) of a larger population of air crashes occurring between the years 1989 through 1994 in Russia also demonstrated this relationship. Although Persinger (1991) speculated that increased geomagnetic activity could produce potentially catastrophic effects within onboard computers, the possible effects of these changes on the pilots themselves were mentioned as an alternative or parallel hypothesis.

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The present study was designed to test the hypotheses that the relationships between numbers of air crashes and increased geomagnetic activity have been related to potential effects upon the pilots' brains as well as on-board computer and electronic systems. If these hypotheses are valid, then the increased geomagnetic activity on the days of air crashes attributed to pilot errors should not have changed over decades. However the intensity of the increased geomagnetic activity over decades for those crashes attributed to computer or electronic errors would have slowly increased statistically, corresponding to the increased complexity (and hence vulnerability) of silicon-based electronic systems.

A total of 373 air crashes between the years 1940 and 2003 were obtained from site² with permission of the Master (R. Kebabjian). Only those events for which the source was clearly identified as either known ($n=102$), mechanical failures (57), electronic or (more recently) computer failures (50), or pilot errors (164) were extracted. The daily global aa (average antipodal) values for geomagnetic activity (in nanoTesla) for the days of the crashes and for each of the three days before and after the crashes were obtained from standard sources.

To test the generalizability of previous observations that air crashes occurred on days when the geomagnetic activity was relatively greater compared to the previous or subsequent days, three two-way analyses of variance with one repeated measure (days) and one between-subject measure (four types of crashes) were completed for the aa values, the log base 10 of the aa values and the day/week ratios of the values. The latter was calculated by dividing the value for each day by the mean for all seven days so that the *relative* activity on the day of the crashes might be enhanced. All analyses involved SPSS software on a VAX computer. *Post hoc* tests included Tukey ($p<.05$) and correlated *t* tests.

The results of the two-way analyses of variance for the raw and log-transformed data (the latter eliminated the heterogeneity of variance across days) demonstrated a statistically significant difference in geomagnetic activity ($F_{3,369} = 3.52, 3.24, p<.001$, respectively; $\eta^2 = .03$) during the week of the crashes. *Post hoc* analysis indicated that the geomagnetic activity on the days of crashes attributed to pilot errors was significantly greater than for those of the other three categories, although the size of the effect was small.

The interaction between days and types of crashes was not statistically significant for the raw data ($F_{18,2214} = 1.51, p<.07$) but was significant statistically for the log-transformed data ($F = 1.72, p<.05$; $\eta^2 = .01$) and ratio data ($F = 1.90, p = .01$; 2% of variance explained). Again, the effect was very

²(<http://www.planecrashinfo.com>)

small. The statistically significant difference between days for all three measures ($F_{6,2214} = 6.59, 5.55, 4.25, p < .001; \eta^2$ about .01) was due, according to *post hoc* tests, to the greater geomagnetic activity on the days of the crashes compared to any of the other six days. As shown in Fig. 1, the source of the interaction between days and type of crash was primarily due to the increased activity on the days of the crashes attributed to electronic or pilot errors relative to mechanical or unknown sources.

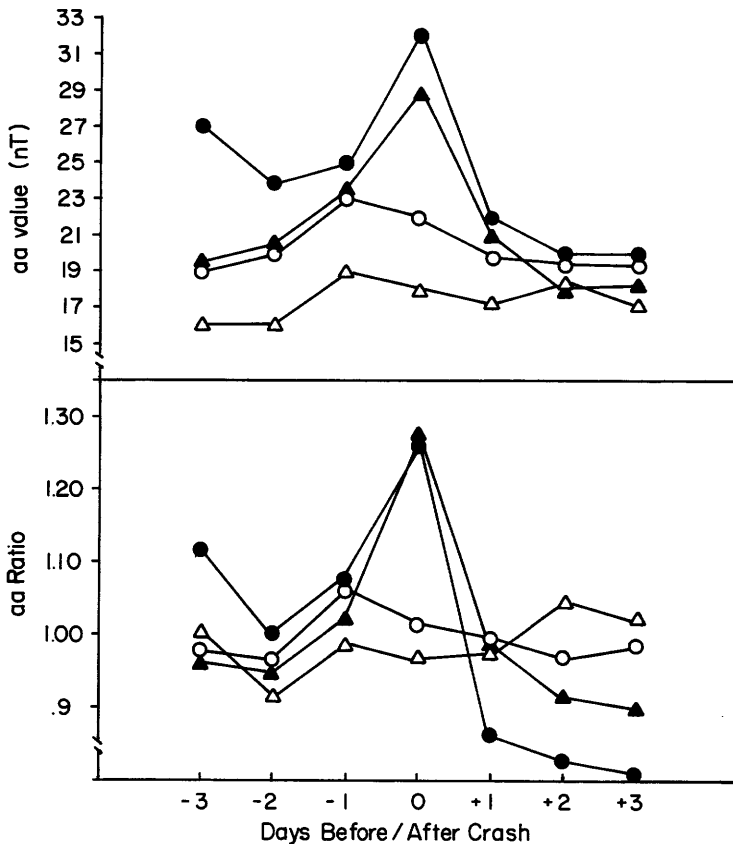


FIG. 1. Mean aa values (in nanoTesla) and aa ratios for the aa value of each day compared to the average for the week for the days before, during, and after four types of air crashes attributed to different sources: unknown ($\circ$), electronic ($\bullet$), mechanical (Δ), pilot ($\blacktriangle$).

The number of crashes within different regions of the world were in North America 107, Central and South America 67, Europe 110, Africa 37, and Asia-Australia 52. Chi-squared analysis ($\chi^2_{12} = 23.97$) indicated a statisti-

cally significant ($p=.02$) discordance among the regions for types of crashes. This mild discrepancy ($\phi_i=.32$) was due in large part to the greater proportion of crashes attributed to mechanical failures in North America (24%) compared to Asia-Australia (6%) and the fewer proportions attributed to pilot error in North America (30%) compared to all other regions (46% to 56%). Two-way analysis of variance for the various measures of aa activity or the ratios of activity on the days of the crashes showed no statistically significant interactions ($F_{12,353} < 1.00$) between types of crashes and locations.

To discern if there were changes over time, numbers of the different types of crashes between 1940 and 1960, 1961 and 1980, and later than 1980 were analyzed for the raw scores for geomagnetic activity on the days of events. Two-way analysis of variance indicated a significant difference ($F_{3,361}=6.47$, $p<.001$; $\eta^2=.22$) in geomagnetic activity on the days of the four classes of crashes. There was also an interaction ($F_{6,361}=2.15$, $p<.05$) between types of crashes and the three bidecades. *Post hoc* analysis indicated that the source of the interaction was primarily due to the increased geomagnetic activity on the days of crashes attributed to electronic errors for the second (1961–1980) and third bidecades (1981–2002) compared to the first (1940–1960) and a decrease in geomagnetic activity on days of crashes attributed to pilot errors during these intervals. The next largest contribution was the inverse relationship between crashes attributed to mechanical errors and unknown causes.

The two-way analysis of variance for the ratio data showed only a statistically significant difference between types of crashes ($F=5.35$, $p<.01$) with no contribution from either the interaction or the bidecades. *Post hoc* analysis indicated that the ratios were significantly higher on the day of the crashes for those attributed to pilot errors or electronic errors compared to the other two categories. A chi-square analysis for the numbers of events during the three bidecades for the four categories demonstrated a statistically significant discordance ($\chi^2_6=28.29$, $p<.0001$; $\phi_i=.27$) due primarily to the reduction (by one-half) of the numbers of crashes attributed to unknown sources and the increases (by a factor of 2 or 3) in the numbers of crashes attributed to mechanical or electronic errors while those attributed to pilots did not change.

To discern the potentially temporal inflection period when the geomagnetic activity became more predominant in the occurrences of the four types of crashes a successive series of one-way analyses of variance were completed for the aa values on the days of the crashes and the ratios for successive 5-yr. periods. The numbers of cases, the means and standard deviations for each increasing aggregate, and the ω^2 estimate (for explained variance) are shown in Table 1. For comparison, the mean and standard deviation for the aa values for the average of the two and three days before the crashes for all

TABLE 1
MEANS AND STANDARD ERRORS OF MEAN FOR GLOBAL AA VALUES (IN nT) FOR EVENTS
ATTRIBUTED TO UNKNOWN CAUSES, ELECTRICAL/COMPUTER ERRORS, MECHANICAL
FAILURES OR PILOT ERRORS AS A FUNCTION OF INCREASING AGGREGATES OF YEARS

Years	<i>n</i>	Unknown		Electronic		Mechanical		Pilot		Omega ² %
		<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	
<1955	74	26	4	23	8	16	3	34	3	9
<1960	116	27	3	23 ^a	9	16 ^a	3	37 ^b	4	8
<1965	160	25	3	27	4	19 ^a	3	33 ^b	3	6
<1970	196	22 ^a	2	30 ^b	4	18 ^a	3	32 ^b	3	6
<1975	223	22 ^a	2	30	5	23	3	32 ^b	3	4
<1980	252	23 ^a	2	31 ^b	4	22 ^a	3	31 ^b	2	3
<1985	273	22 ^a	2	32 ^b	3	21 ^a	3	30 ^b	2	4
<1990	304	22 ^a	2	32 ^b	4	20 ^a	3	30 ^b	2	4
<1995	336	22 ^a	2	32 ^b	3	20 ^a	3	30 ^b	2	4
<2002	373	22 ^a	2	32 ^b	3	18 ^a	3	29 ^b	2	5

Note.—*n* = number of crashes. Omega² estimates (explained variance) are indicated.
^a vs ^b *p* < .05.

cases were 21.0 and 14.0, respectively. The differences between the four types of crashes for this baseline was significant ($F_{3,335} = 2.69$, *p* = .05).

The values for the ratios of geomagnetic activity on the day of the crashes compared to the average of the week are shown in Table 2. For both tables the primary source of the differences was the increased geomagnetic activity on the days of crashes attributed to pilot error. However, the geomagnetic effect for crashes attributed to computer and electronic errors became more evident only when all cases after 1965 were added to the previous aggregate.

These results support our general hypothesis that some factor or factors

TABLE 2
MEANS AND STANDARD ERRORS OF MEAN FOR RATIOS OF AA VALUES ON DAY OF CRASH TO MEAN
OF WEEK FOR EVENTS ATTRIBUTED TO UNKNOWN CAUSES, ELECTRICAL/COMPUTER ERRORS,
MECHANICAL FAILURES OR PILOT ERRORS AS A FUNCTION OF INCREASING AGGREGATES OF YEARS

Years	Unknown		Electronic		Mechanical		Pilot		Omega ² %
	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>	
<1955	1.05	.10	1.00	.26	.93	.10	1.25	.09	9
<1960	1.05	.08	1.07	.17	.88	.09	1.30	.08	7
<1965	1.00 ^a	.06	1.09	.14	.95	.08	1.24 ^b	.06	5
<1970	.93 ^a	.06	1.25	.14	.94 ^a	.07	1.24 ^b	.06	8
<1975	.97 ^a	.06	1.22	.14	.99	.08	1.24 ^b	.06	5
<1980	1.00 ^a	.06	1.19	.12	1.00	.08	1.25 ^b	.06	4
<1985	1.00 ^a	.06	1.18	.11	1.00	.07	1.25 ^b	.06	4
<1990	1.00 ^a	.05	1.21	.11	1.00 ^a	.07	1.26 ^b	.06	5
<1995	0.99 ^a	.05	1.23	.08	1.02 ^a	.06	1.28 ^b	.06	5
<2002	1.02 ^a	.05	1.28 ^b	.06	0.98 ^a	.06	1.28 ^b	.05	4

Note.—Omega² estimates (explained variance) are indicated. ^a vs ^b *p* < .05.

associated with increased geomagnetic activity can disrupt the normal processing of information within complex electronic systems that include human brains (of pilots) and sophisticated computers. We are assuming that the sources responsible for the four categories of crashes were relatively homogeneous. We also appreciate that the validity of the attribution, such as "pilot error," may be questionable. These cases may not be related to intent, negligence, or fatigue but to interactions between machine and pilot of which we are not currently aware.

The effect size was quite small, explaining no more than about 9% of the variance for the differences between types of crashes. Direct causal effects were not likely to be operative for the entire set of crashes. Instead, a unique set of conditions that occurred infrequently and were specific to a subset of crashes may have been produced by increased geomagnetic activity. One analogy would be the marked vulnerability of specific receptors to a particular molecular structure (out of millions of possible structures) that can produce "catastrophic changes" in ion channels. We speculate that intensity *per se* is not the critical variable. Instead there may be intrinsic frequencies or temporally structured patterns (Belisheva, Popov, Petukhova, Pavlova, Osipov, Tkachenko, & Baranova, 1995; O'Connor & Persinger, 1997; Cherry, 2002) associated with specific bands of intensity that may affect the functioning of computerized electronics or even the decision-making processes of the pilots.

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